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Discrimination of Unique Biological Communities in the Mississippi Lignite Belt

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Submitted to

The Mississippi Natural Heritage Program

By

W. Frank Miller, Director
James D. Cutler, Graduate Research Assistant
The Mississippi Remote Sensing Center
P. O. Drawer FD
Mississippi State, MS 39762

In Fulfillment of Contract 80-4-174

Revised July 1981

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INTRODUCTION

As a result of energy demands that our country now faces, lignite coal deposits in Mississippi have recently come under study as a potential source of recoverable fossil fuels. Based on estimates calculated from 750 drill holes, Mississippi has approximately five billion tons of surface mineable lignite which is equivalent to ten billion barrels of oil, and ranks second only to Texas among the Gulf Coast states with respect to these lower grade reserves.[1] A "belt" of lignite deposits presently exists in northern and east-central Mississippi, and with respect to Mississippi topography, surface mining methodologies appear to be the most efficient and economical form of recovery.[1] The belt can be divided into two commercially important sections, the first from north of Marks, in Quitman County, through western Panola County into Lafayette County. The second section originates in Lauderdale County, extends into Kemper, Neshoba, Winston, and Choctaw Counties, and ends at Webster County. Counties where the deposits are not considered to be as valuable in today's economic climate are Tallahatchie, Yalobusha, Grenada, Calhoun, Carroll, and Montgomery (Figure 1).

Since the surface mining of lignite will undoubtedly have environmental impacts on the local landscape where the extraction occurs, it is imperative that areas of unique or historical ecological habitat

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[1]Address by W. R. Bohon, President, Phillips Coal Company, October 24, 1979, to Governor's Conference on Energy and Economic Development, Jackson, MS.

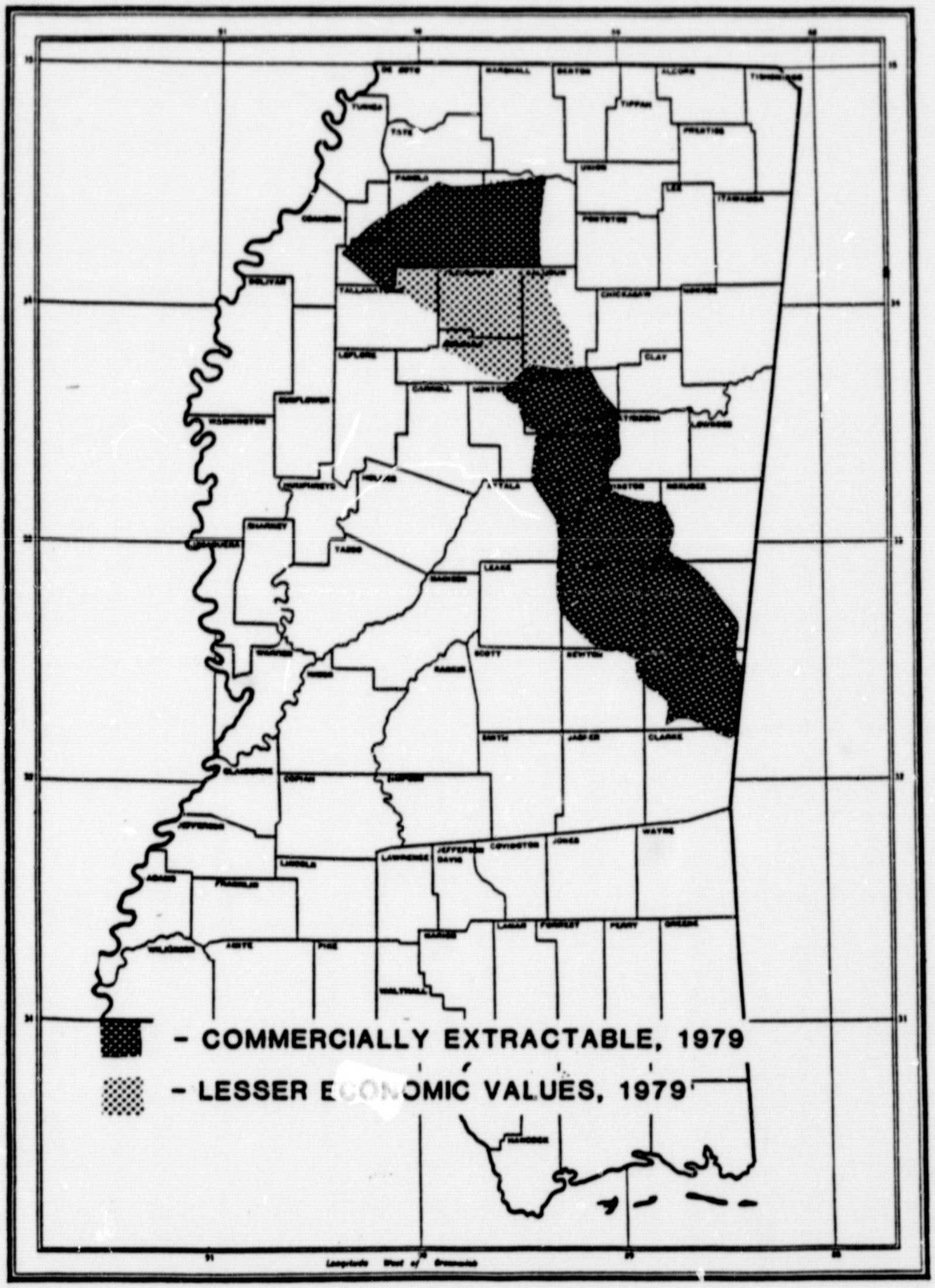

Figure 1. Potential lignite deposits in Mississippi.
From: An investigation of the Tertiary lignite of Mississippi. D. C. Williamson. Miss. Geological Econ. Survey Info Series MGS, 74-1, 1976.

types within the belt be located, documented and, if possible, preserved. One such habitat type under scrutiny is old growth hardwood stand remnants, especially those which have not been seriously affected by agriculture, grazing, timber harvesting, fire, or any natural catastrophe which caused stand deterioration.

It was the purpose of this study, as contracted by the Mississippi Natural Heritage Program (MNHP), to develop cost-effective remote sensing techniques for identifying large, contiguous areas of old growth hardwoods within Mississippi's lignite belt that do not exhibit signs of recent disturbance, and to identify and map such areas.

PROCEDURE

Summary

General implementation of this study was carried out in three phases, with the intent of employing a multistage sampling technique. The proposed procedure was to first synoptically survey the study area on small scale Landsat hardcopy prints and select areas of interest for more detailed analysis with digital satellite data. Areas indicated through the second phase analysis would then be flown with color infrared (CIR) aircraft imagery for very intensive site analysis. Due, however, to fiscal constraints of the contractor, it was necessary to fly the areas selected through manual interpretation of the small scale Landsat hardcopy. The actual procedure employed is summarized as follows.

Phase I employed hardcopy Landsat satellite imagery to detect areas of deeply dissected terrain where a high probability of undisturbed, old growth hardwood stand remnants existed. The existence of

these stands was hypothesized by the relative difficulty of logging due to steep slopes and broken terrain. Phase II employed medium altitude aircraft overflights of areas selected in Phase I, with the resultant imagery being examined in the laboratory for location of sites exhibiting the greatest potential for hardwood stand remnant occurrence. Most of these potential sites were then surveyed and evaluated in the field and in the laboratory. Due, however, to time and financial constraints, not all potential sites were field checked. The compiled results were subsequently disseminated to botanists for further study. Phase III consisted of the development of an information system using land cover classes derived from digital Landsat data, geology, hydrology, soils, and cultural activity. With the input of the computer-assisted land cover classification, locations of all hardwood stand remnants in the lignite belt subject to mining influence were determined for future decision-making analysis and evaluation.

A complete discussion of each phase and their results follows.

<u>Phase I Operations</u>

In this phase, interpretation of 1:250,000 scale, Band 7 Landsat imagery was made ocularly with the aid of hand magnifiers in order to locate areas deeply dissected terrain where a relatively high probability of undisturbed, old growth hardwood stand remnants might exist. A mylar overlay was prepared and superimposed onto a Landsat color composite in order to delineate areas predominantly of hardwood forest stands within the rough terrain. Large contiguous areas of bottomland hardwoods on major drainages within the study area were also noted since these areas might be impacted by secondary effects of mining.

An interpretation key developed for the hardcopy Landsat analysis is provided in Appendix I.

Phase II Operations

Imagery Acquisition.

Phase II was initiated with aircraft overflights of areas selected from coverage obtained in Phase I. The flights were centered on areas identified as having a high potential for containing old growth stand remnants on the basis of manual interpretation of Landsat Band 7 and color composites of the project area. Color infrared (CIR) imagery was obtained during the first two weeks of November, 1979, at a nominal scale of 1:24,000. Overall, forty-seven flight lines covering twenty-three areas were flown producing a total of 679 individual image frames for image interpretation. The data produced consisted of four positive transparency film rolls, a full set of 9 x 9 inch paper prints, and a half set of prints representing alternate frames. Coverage obtained included portions of the following counties: Calhoun, Choctaw, Grenada, Kemper, Lafayette, Lauderdale, Marshall, Montgomery, Noxubee, Oktibbeha, Panola, Tallahatchie, Webster, Winston, Yalobusha, and a small portion of Attala (Figure 2).

Imagery Analysis.

Once the CIR imagery was obtained, the selection of potential sites was undertaken. In the initial location of these sites, the four film rolls were scanned using a light table and a lens magnifier and general areas were identified which had characteristics suggesting the necessity for closer analysis. The characteristics used included

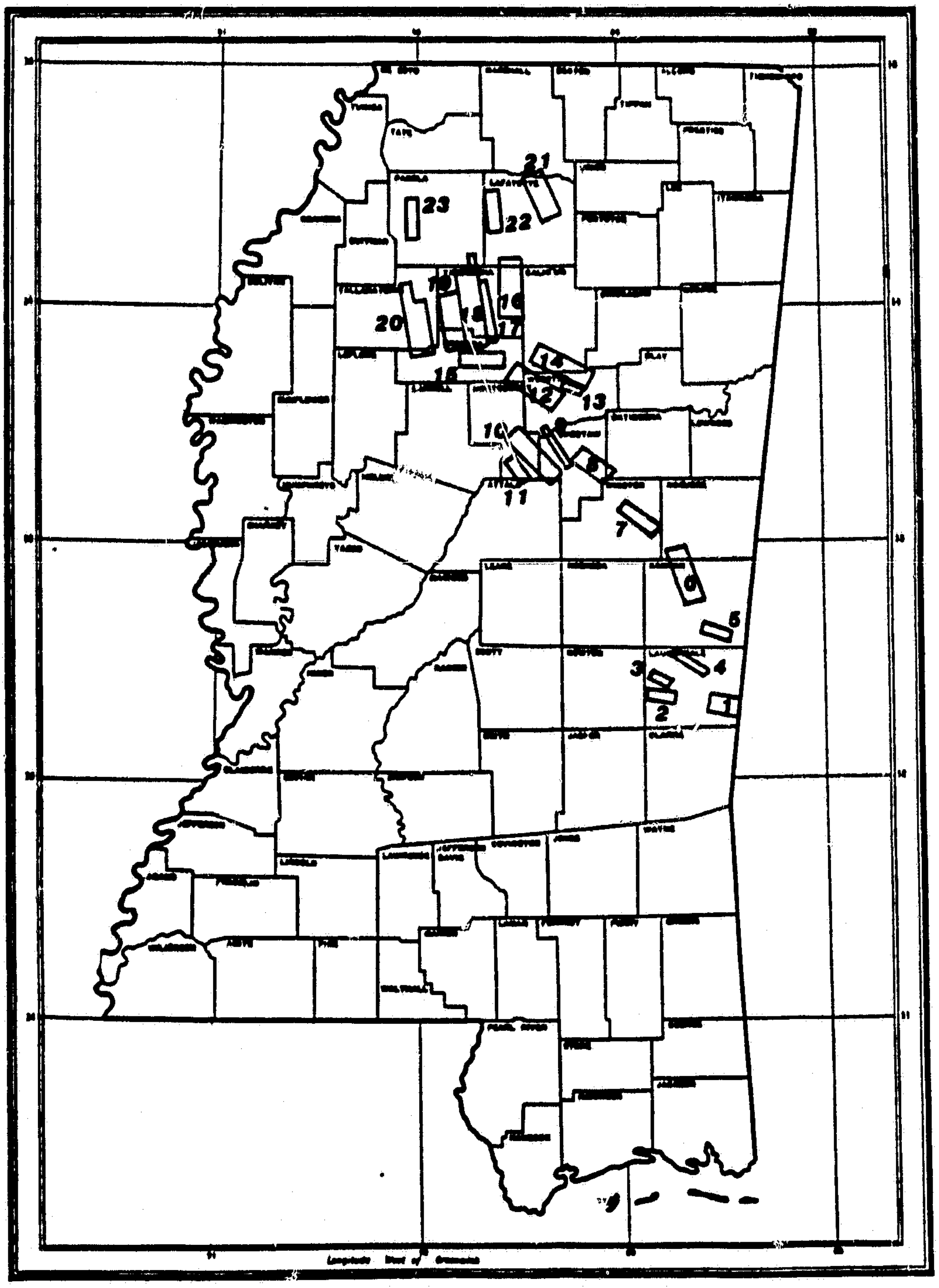

Figure 2. Phase II aircraft overflight areas selected from Phase I coverage (23 separate overflight areas).

stand composition, area size, degree of terrain dissection, proximity to cultural activity, diameter range of dominant and free-growing trees (Figure 3), crown diameters, and evidence of logging or other disturbance within the area. Although these characteristics were employed more or less intuitively on the general scan, quantification of some terms emerged as the study progressed. As general areas were identified, a zoom stereoscope was then used to achieve a three dimensional view of the sites for discrimination of finer details. Basically, the "potential" sites selected for more detailed examination were those which exhibited old growth (large crowned) hardwood stand remnants occurring in dissected, rough topography with little or no evidence of recent disturbance; i.e., agricultural uses, timber removal, or other cultural activity. Hardwood bottoms were also selected as ecological communities likely to be influenced by mining pressure. Inevitably, all sites varied in some degree from each other with respect to forest stand and site characteristics. These characteristics included average tree crown size, stocking of large residual stems (per acre), general topography, total acreage, evidence of past disturbance within the site, and the proximity of surrounding disturbance to the site's boundaries (potential threat). The latter characteristic was based on evidence of the intensity of cultural activity in the vicinity of the area; i.e., road construction, new home site, urban development, stream channelization, or silvicultural activities adjacent to the areas. From visual image analysis of these characteristics, all identifiable potential sites were given a potential rating of very good (1), good (2), average (3), or poor (4); these initial

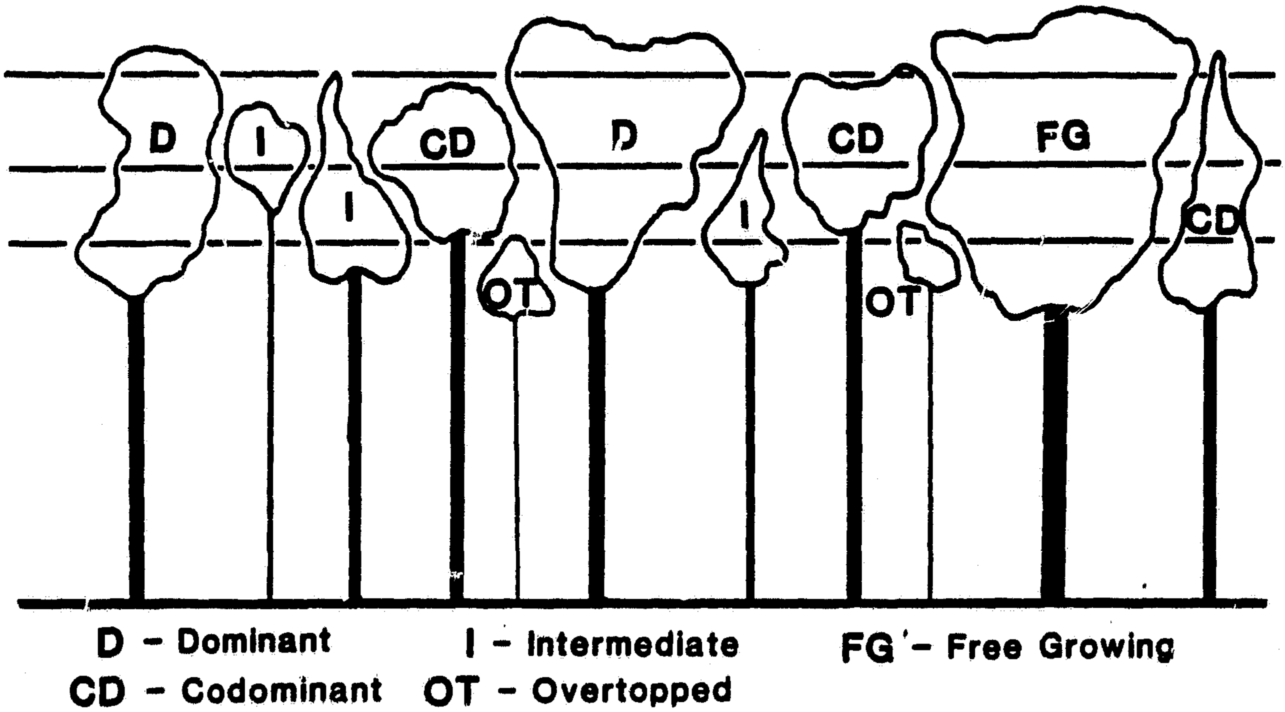

Figure 3. Crown Classes Within an Evenaged Stand.

ratings were assigned intuitively, based largely on a concept of what constituted a "good" site. The quantified rating criteria which emerged from this preliminary analysis used for the sites are presented in Table 1. A twenty-acre stand size was selected as one of the criteria for a Class 1 rating primarily because it generally insures an interior five acre (8 ch. dia.) area with a buffer zone of 15 acres (additional 4 ch. radius). This buffer requirement is based on the limits of observed "edge" effect of low level cultural activity on the periphery of a stand. The disturbance or cultural activity criterion was developed on both an intensity or degree of activity factor and proximity of the activity to the site. If a site was proximate to a high intensity cultural activity such as an industrial site, it was excluded from consideration. Only low intensity activity such as logging, agricultural uses, recreational uses, or single family home sites were considered as acceptable. The degree of these activities is only relative, one area to another, for rural areas. To aid in acreage determination and hardwood crown diameter estimation, a mylar acreage overlay and crown diameter wedge were used. Once a potential site was located on the transparency rolls, and its rating established, a U. S. Geological Survey quadrangle map (7.5 or 15 minute) was selected which contained the area under study. From the quad maps, information including quad name, county, section, township and range, and ownership, if shown on the map, was also recorded. Directions to the sites were briefly outlined using highway and quad maps and CIR transparency rolls. In the ensuing field studies,

Table 1. Rating Criteria

#1 Rating. <u>All</u> of the following must be met:

1. Site 20 acres or more in size
2. No evidence of recent disturbance <u>within</u> site (i.e., grazing, logging, agricultural)
3. Hardwood crown diameter 40 - 60'
4. Stocking of large-crowned hardwoods greater than 10 per acre
5. No evidence of disturbance within 1500' of site boundaries (i.e., agricultural, forestry, home sites, recreational)

#2 Rating. Generally includes the following:

1. Evidence of recent disturbance minimal within site, and/or
2. Hardwood crown diameters 20-40', and/or
3. Stocking of large-crowned hardwoods less than 10 per acre, and/or
4. Evidence of disturbance within 1500' of site boundaries

#3 Rating. Generally includes the following:

1. Evidence of recent disturbance within site greater than for a #2 rating, and/or
2. Hardwood crown diameters less than 30', and/or
3. Stocking of large-crowned hardwoods less than 5 per acre, and/or
4. Evidence of disturbance within 1000' of site boundaries

#4 Rating. Generally includes the following:

1. Evidence of recent disturbance within site greater than for a #3 rating, and/or
2. Hardwood crown diameters less than 15', and/or
3. Stocking of large-crowned hardwoods non-existant

corresponding individual CIR photos were pulled from the full set, marked with true north and site boundaries outlined in grease pencil, and taken into the field to assist in site location. Also recorded were maximum/minimum site elevation (from the quad maps), physiographic province information (Hodgkins, et. at., 1976), and approximate site acreages estimated from the CIR imagery using the mylar acreage overlay. Some site areas were broken down into subsites (designated by A, B, C, ..., n) due to disruption of hardwood homogeneity by pine influence. These subsites were subsequently designated on all CIR imagery. All sites to be surveyed were located on a general state highway base map, and recorded for lab and field referral. Furthermore, pertinent CIR imagery data including roll, flight, frame, site identification number, filming date and scale were recorded for each site. Finally, the "source of lead," or form of information which led to the detection of a potential site, was determined. At this point, only two sources were available--Landsat or CIR imagery. All potential sites were located from the CIR imagery, with some being referenced both to CIR and Landsat data sources.

Field Techniques.

In order to verify the actual location of old growth hardwood stand remnants and to confirm ecological community structure, field studies were conducted upon potential sites identified on the CIR imagery with ratings of two (2) or three (3); no number one rated sites were found. Although field data were collected on a MRSC form, a standard Site Survey Summary Sheet was developed by the Mississippi Natural Heritage Program for use in permanently recording both laboratory and field data on these selected sites. Only a portion of the

summary sheet was completed in the lab where information could be obtained from various maps and CIR imagery.

To permit the field location of the potential sites chosen for surveying and data acquisition, general county highway maps, and CIR frames were utilized. Once a site was located, various forest stand and site data were collected in order to develop a representative ecological description of the site (Appendix II, p.41). Two or three-man crews walked through the sites and chose points representative of the overall topography, including ridge tops, upper, middle and lower slopes, and creek bottoms. For those sites consisting entirely of flatwoods topography (alluvium), only one topographic position was represented. At some points, no quantitative data were taken, primarily because of high vegetative homogeneity, but qualitative data were obtained in order to provide a general ecological description of the site. Such data included a listing of the dominant overstory species[2], understory (shrub) and ground vegetation species, and a determination of slope gradient (percent). A brief mention was also made of any unique ecological conditions found on the sites, including mass wastage, wildlife habitat potential, and unique hydrologic conditions as examples. At points where quantitative data were collected, a one-twentieth (1/20) acre plot was established, and with the aid of a 10 BAF[3] prism (Dilworth and Bell, 1976), overstory trees were

[2]Most frequently occurring species in the main crown canopy

[3]BAF: basal area factor where basal area is the cross-sectional area of the stems tallied at 4.5 feet above ground.

tallied by species and recorded. For each overstory tree in the 1/20 acre plots, diameter at breast height (DBH) was measured using a DBH tape or tree calipers, and its corresponding crown position in the stand canopy (Hocker, 1979) established; i.e., free-growing, dominant, codominant, intermediate, or overtopped (Figure 3). Heights of tallied trees were initially determined using a Haga altimeter, but were later ocularly estimated because of time constraints. Crown diameters of dominant and free-growing trees were estimated from the average of two paced lines run on cardinal bearings (Table 2).

Understory tree species were also tallied by 10-BAF prism. DBH was measured for each individual tree tallied, with heights being ocularly estimated. Ground vegetation within the area was recorded by species occurrence, but no quantitative data were recorded (Table 2).

Finally, additional information recorded included mention of the presence on the sites of unique or unusual edaphic site conditions, slope gradient, ownership, and topographic position; i.e., ridgetop, sideslope, creek, or alluvial plain.

Combined Image Analysis and Field Work

After field surveys were completed, laboratory site analysis and evaluation was carried out in order to develop an ecological description of the site. Initially, under the "site description" section of the Site Survey Summary Sheet (Appendix II), a written analysis of the site was made beginning with a brief description of the local topography. This included mention of general topographic relief defined qualitatively as flat, gently rolling, slightly dissected, dissected, or highly dissected, and an approximation of overall slope gradient

Table 2. Field Data Collection Sheet

SITE_____ ROLL #_____ FRAME #_____ DATE____________ CREW_______________________

Point #	Species	DBH (in.)	Cr. Dia. (ft.)	Ht. (ft.)	Cr.Cl.	Comments

occurring over the site. The degree of dissection was based largely on the frequency of occurrence of lateral streams and large gullies. A pattern which presented a "fine" texture or highly dissected area was represented by terrain with lateral drainage or major gullies occurring at intervals of 200 -600 feet.

A description of the soil associations representative of the sites followed, with emphasis on soil textural and drainage classes. This information was obtained from the Soil Conservation Service (SCS) County Soil Association or Soil Survey maps.

In addition to general inventory data, a major component of these site descriptions consisted of a short narrative describing the principal overstory, understory, and ground vegetation species presented. Emphasis was also placed upon the extent of occurrence, from rare to abundant, of understory and ground vegetation. Mention was then made of any observed ecological components which might aid in the description of a site. Included was the presence of sloughs or other hydrologic features, the abundance of large "virgin" timber or unique species of flora, and evidences of mass wastage, extreme slope gradients, geologic disconformities, recreation or wildlife potentials, or any other unique inherent characteristic (Appendix II).

To further aid in the site descriptions, a short discussion of the surrounding land uses and evidences of disturbance for each site was briefly included. Under "evidences of disturbance," any potential threat to the site such as logging, agriculture, or cultural activity was listed with respect to distance and direction from site boundaries.

Surrounding land use practices; e.g., forestry, agriculture, residential, industrial, recreation and cultural, adjacent to the site were also discussed.

Finally, a classification code, developed by the Mississippi Natural Heritage Program from the Society of American Foresters' (SAF) Forest Cover Types of North America, was assigned to each site (Appendix III), along with Mississippi physiographic province plant community designations (Table 3). These classification codes attempted to describe, in abbreviated form on the Site Survey Summary Sheets, a site's biological and edaphic components. As might be expected, problems were encountered in applying regional classification schemes such as the SAF types to individual stands. Forest types maintain a much higher level in the hierarchical classification than a component stand in that type. As with any classification of this type, the number of individual categories at successively lower levels must proliferate in order to fully describe all components.

Site analysis also included the quantification of field measurements made on the overstory and understory components. For each site where quantitative data were taken of the overstory, a determination of basal area was made for each individual tree species and for the entire site (Table 4). Additionally, mean and range values for DBH and tree height were computed by species. Quantification of understory data included the determination of the approximate number of understory trees greater than one inch DBH for each species present per acre over the site (Table 5). Ground vegetation description consisted of the listing of major species occurring on each site (Table 5). For

Table 3. Mississippi Physiographic Province Plant Communities

TR	Tennessee River Hills
NP	Northeastern Prairie Belt (Black Belt)
PR	Pontotoc Ridge
FW	Flatwoods
NC	North Central Plateau
JP	Jackson Prairie
LB	Loess Bluff Hills
YD	Yazoo-Mississippi Delta
LP	Longleaf Pine Belt
CP	Coastal Pine Meadows

Table 4. Overstory Summary Work Sheet

Site#____________ Date Surveyed____________

# of points________ 10 BAF Prism

Overstory

Species	Total # of trees tallied	BA/acre (Sq.ft)	DBH		Total Height	
			Mean (in.)	Range (in.)	Mean (ft.)	Range (ft.)
	TOTAL BA/ac.					

Table 5. Understory - Ground Vegetation Summary Work Sheet

Site #________________

Date Surveyed________________

\# of plots____________

1/20 acre circular plots

Understory

Species	#/acre

Ground Vegetation

Species occurring

those sites where only qualitative descriptions or partial quantitative data were obtained, portions of Tables 4 and 5 were not utilized. A decision was also made with respect to the potential degree of threat affecting each site based upon the evaluation of surrounding land uses and evidences of disturbance within or adjacent to the site. A site was therefore described as either "threatened," "potentially threatened" or "secure" (Appendix II).

Phase III Operations

Digital Landsat Analysis.

In this phase, an image classification/pattern recognition analysis to develop a unique "hardwood" signature was accomplished utilizing Landsat multispectral scanner (MSS) data. One Landsat frame contains coverage of over 7.5 million pixels. A pixel is a Landsat picture element which represents approximately 1.1 acre of ground surface. Due to the large size of the area, it was necessary to obtain data from two Landsat frames, which in combination image over 23,000 sq. mi. of central and northern Mississippi. Of this, about 7,238 sq. mi. (4,632,320 acres) were actually classified for analysis.

The major software employed in this analysis was the EOD/LARSYS package. This software was modified from the Purdue University Laboratory for Application of Remote Sensing package by the Earth Observation Division of the Johnson Spacecraft Center.

Five training fields were selected in an effort to represent at least one each of the major physiographic provinces of the study area; i.e., the Alluvial Floodplain, the Deep Loess, and the Hilly Coastal Plain. Through use of grayscale maps of the Landsat data, the training fields were located and identified. The areas ranged from

approximately 5,000 to 10,000 acres in size. The ISOCLS algorithm within the EOD/LARSYS package was then utilized to generate alpha-numeric maps of the training models, which contained 31 ordered statistical groups (clusters) representative of the varied spectral signatures present. Through use of available interpretive equipment and 1:24,000 CIR imagery of the training fields, the statistical groups identified by the ISOCLS processor were further grouped into cover class types of significance for this project.

With the signatures grouped according to their land cover types, the classification analysis was further refined through employment of the CLASSIFY processor. This processor redefined all standard deviations and covariance matrices previously generated by the ISOCLS processor, and subsequently grouped all pixels over the entire study area by maximum likelihood of occurrence. These data were written on digital tapes (MAPTAPS); after completing classification, the resulting map of the study area was then reformatted for geo-registration through use of a color graphics/image display system. The central unit of this system is the Data General S/130 minicomputer. Geo-registration was necessary to correct the angle distortion characteristic of the data. The 1.1 acre pixel cells were then collapsed into 45-pixel (approximately 50 ac.) cells, and inserted into the data base. Accuracy of the classification was determined by selecting check areas in three different portions of the study area. One area was in the vicinity of Okatibbee Lake in Lauderdale County, the second was in the central part of the area in Attala and Winston Counties, and the third area was in the vicinity of Grenada Lake. Aerial imagery of each area was available, and these data were used to determine the discrimination accuracy of the Landsat classification.

Data Base Development and Modeling.

A 50 ac. grid was selected for a data base to be used in management of the information collected in this study. The data base consisted of eleven (11) information levels (variables) illustrated in Table 6.

Upon completion of variable input to the data base, user-defined modeling procedures were performed utilizing CALUP (Computer-Assisted Land Use Planning) software. This software package was developed by personnel of the Computer Science Department at MSU over a number of years (1977-81) for operation both on the mainframe host computer (Univac 1100/80 Executive), as well as the MRSC Data General S/130 minicomputer. The package contains a series of programs that utilize additive function overlaying of variables to produce user controlled 'ideal' conditions for solving various environmental problems faced by land use planners in real world situations; i.e., sites for industrial waste or flash flood hazard areas. CALUP is utilized mainly on the Data General system as an interactive color graphics display program, and output is by line printer or sequential camera/recorder.

RESULTS

Phase I and II

After a site was completely analyzed and evaluated, a permanent rating of acceptability was assigned to it. Ratings for all the selected sites which were either (1) laboratory and field surveyed, or (2) evaluated only in the laboratory through photo-interpretation, are listed in Table 7. The rating criteria previously developed are presented in Table 2. Overall, there were no number one (1), 25 number two (2), and 30 number three (3) rated sites. No number four (4)

Table 6. Unique Forest Habitat Data Base - Fifty Acre Cell Size

<u>1</u>	<u>Topography</u>
0	No Rough Topography
1	Rough Topography
<u>2</u>	<u>Soil Orders</u>
0	Void
1	Alfisols (Wet)
2	Alfisols (Moist)
3	Entisols (Wet)
4	Entisols (Moist)
5	Inceptisols (Wet)
6	Ultisols (Moist)
<u>3</u>	<u>Soil Associations</u>
0	Water or Void
1	Nearly Level, MWD and SPD, Silty: Alluvium, Delta and Loess
2	Alluvial, Flood Plains, SPD and PD, Silty and Clayey
3	Deep Loess
4	Sandy Clay Hills
5	Thin Loess and Coastal Plains
6	Alluvial Terrace With Pan
7	Thin Loess
8	Slackwater Flats
9	Silty Terrace
10	Delta-Medium Texture Wet
<u>4</u>	<u>Hardwood Forests - Landsat Imagery</u>
0	Void
1	Forests
<u>5</u>	<u>Cultural</u>
0	Void
1	Roads
2	Cities
3	Railroads
4	Airports
<u>6</u>	<u>Hardwood Forests - County Foresters</u>
0	Void
1	Hardwoods
2	Pine
3	Mixed
4	Other - Not Identified
5	Contradictory
6	Unknown

Table 6 - Continued

<u>7</u>	<u>Water</u>
0	Void
1	Lakes
2	Rivers
3	Major Streams
<u>8</u>	<u>Hardwood Sites (Low Altitude Color I.R.)</u>
0	Void
1	Hardwood Site
<u>9</u>	<u>Counties (North Part of DB)</u>
0	Void
1	Tunica
2	DeSoto
3	Tate
4	Quitman
5	Panola
6	Lafayette
7	Tallahatchie
8	Yalobusha
9	Calhoun
10	Grenada
11	Chickasaw
<u>10</u>	<u>Counties (South Part of DB)</u>
0	Void
1	Montgomery
2	Webster
3	Clay
4	Choctaw
5	Oktibbeha
6	Winston
7	Noxubee
8	Kemper
9	Lauderdale
<u>11</u>	<u>Land Cover From Landsat Imagery</u>
0	Void
1	Undefined
2	Hardwood Predominates
3	Inert. Highly Reflective
4	Water

Table 7. Designated ratings for all potential sites.

County	Site #	1:24,000 Aerial Data Role	1:24,000 Aerial Data Frame	Stand Rating
Choctaw (CHOC)	1	4	2	2
	2	4	7	2
	3*	3	125	3
	4	3	165	2
Grenada (GR)	1	2	1	2
	2	3	19	2
	3*	3	1	2
	4	3	18	2
	5*	3	4	3
	6	3	5	3
	7*	3	13	2
	8	1	148	3
	9	2	66	2
	10	2	68	2
	11*	2	93	3
	12*	2	95	2
	13*	2	97	2
	14	2	98	2
	15	1	169	2
Kemper (KEM)	1	4	93	2
	2	4	92	2
Lafayette (LA)	1*	1	24	3
	2	1	29	3
	3	1	40	3
	4*	1	66	2
	5*	1	24	2
	6	1	50	3
	7	1	55	3
Lauderdale (LAUD)	1	4	66	2
	2*	4	46	3
	3	4	60	3
	4	4	73	3
Marshal (MA)	1*	1	64	3

*Indicates site was only laboratory-evaluated.

Table 7 - Continued

County	Site	1:24,000 Aerial Data Role	Frame	Stand Rating
Montgomery (MONT)	1*	3	121	3
	2	3	99	3
Oktibbeha (OK)	1*	4	17	3
Panola (PA)	1	1	176	3
	2	1	4	3
	3	1	7	2
	4	1	8	2
	5*	1	9	3
Tallahatchie (TA)	1*	2	84	3
	2*	2	88	3
	3	2	115	3
	4	2	113	3
	5	2	110	2
Webster (WEB)	1	2	169	3
	2*	3	44	2
	3*	3	86	2
	4*	3	92	3
	5*	2	136	3
	6*	2	158	3
Yalobusha (YA)	1*	2	28	3
	2	1	147	3
	3	1	184	2

sites were considered. The reason for the absence of number one (1) sites was due to strict application of the rating criteria. It should be stressed, however, that sites with a two (2) rating are very good and were utilized in more intensive analyses. Number three (3) sites were also viable and were not discounted. No suitable areas were located in Neshoba, Winston, Carroll, Calhoun, and Quitman Counties.

Once a Site Survey Summary Sheet was completed, the compiled information was distributed to three botanists and the Director of the Mississippi Natural Heritage Program. The botanists later surveyed over half of the sites to obtain data concerning rare and endangered species of flora. Each botanist was given those sites which were located within a general area relative to his base of operations. Copies of the Site Survey Summary Sheets, field and lab data sheets, county highway maps, and a CIR photo from the half set of prints were sent to the botanists to aid in site location. When a photo could not be sent, a xerox copy was used in its place.

Thirty-one of the plots were visited by the botanists. Of these 31 sites, 17 either contained rare and endangered plants at the time of visitation, or were subjectively rated as having a moderate to high potential for containing rare and endangered plants. The sites which contained rare species are listed in Table 8, together with their representative plant component. A comparison of the foresters' and botanists' rating of the plots is presented in Table 9.

Phase III

Digital Landsat Analysis.

Since only the hardwood and predominantly hardwood forest stands

Table 8

Rare Plant Findings by Botanists

Site	Plant
GR # 3	*Cypripedium calceolus*
GR # 6	*Schisandra glabra*
GR # 9	*Trillium recurvatum*
GR # 9	*Matelea carolinensis*
GR # 9	*Osmorhiza spp.*
GR #10	*Osmorhiza longistylis*
GR #14	*Echinacea purpurea*
LA # 3	*Salvia urticifolia L.*
TA # 3	*Osmorhiza spp. longistylis*
TA # 4	*Pachysandra procumbens* Michaux
TA # 5	*Cypripedium calceolus*
TA # 5	*Matelea carolinensis*

Table 9. Comparison Between Botanists and Foresters Ratings of Plots

Site	Botanists' Rating	Foresters' Rating
CHOC. 1	2	2
GR. 3	1	2 (not field surveyed by foresters)
GR. 6	1	3
GR. 8	1	3
GR. 10	1	2
GR. 14	1	2
KEM. 1	1	2
KEM. 2	1	2
LA. 3	1	3
LA. 6	1	3
LAUD. 3	1	3
MONT. 2	2	3
TA. 3	1	3
TA. 4	1	3
WEB. 1	1	3
YA. 2	1	3
YA. 3	1	2

were of consequence in the study, major emphasis was placed in developing spectral signatures for these land cover classes. Signatures were also developed for inert material and water in order to assist in geo-referencing the computer classified data to the data base. Based on this analysis, a total of 22,168 fifty-acre cells (24%) were classified as predominantly hardwood forest composition, 11,052 cells (12%) as inert, and 2,123 cells (2.3%) as water. Fifty-two thousand five hundred and ninety-six (52,596) cells (59.9%) which represented all other land use cover not significant to the objectives of this study; i.e., pines, fallow land, and agriculture, were grouped into an "other" category. Of the study area initially defined, 4,711 cells (5.1%) did not have satellite coverage on the two tapes purchased. Thus, the study area was composed of 4.63 million acres of which 1.11 million acres were classified as predominantly hardwoods. In order to test the accuracy of the classification, three test areas were selected for which aerial imagery was available and evaluated with the computer classification. Acreages of known cover types identified by interpretation of the aerial imagery were calculated using modified acreage dot grids and compared to pixel-by-pixel counts of the same cover types on the classification output. Acreage estimations from this procedure resulted in from 83-85% accuracy for the dominant hardwood stands tested. Difficulties were encountered in separating mixed pine-hardwood forests from pure hardwood forests, so there was overlap between these two signatures. A unique signature for pure pine forests was, however, developed with almost no spectral overlap. Several wetland and water edge effect signatures were found, but they were

subsequently grouped into the single subclass of water.

Modeling.

The summation of acreage estimates of the four (4) hardwood information sources utilized in this study are as follows:

(1) Informant data - county foresters, ASCS personnel, county agents:

2,549 cells (127,450 ac.) in hardwoods;

689 cells (34,450 ac.) in pine;

1,047 cells (52,350 ac.) in mixed stands;

148 cells (7,400 ac.) of conflicting information.

(2) Landsat hardcopy data:

18,901 cells (945,050 ac.) in rough terrain

(3) Landsat digital analysis:

22,168 cells (1,108,400 ac.) in hardwoods;

11,052 cells (552,600 ac.) in inert features;

2,123 cells (106,150 ac.) in water;

52,596 cells (2,629,800 ac.) in "other" land cover

(4) Old growth stand acreage identified from 1:24,000 CIR imagery:

91 cells (4,550 ac.) in old growth hardwoods.

Although the areas identified from the imagery were generally less than fifty (50) ac., they were input as occupying the minimum cell size of 50 ac. A comparison of this hardwood site source information was accomplished by a computer-assisted additive function process called 'modeling' (Figure 4). The results of this modeling effort (Table 10)

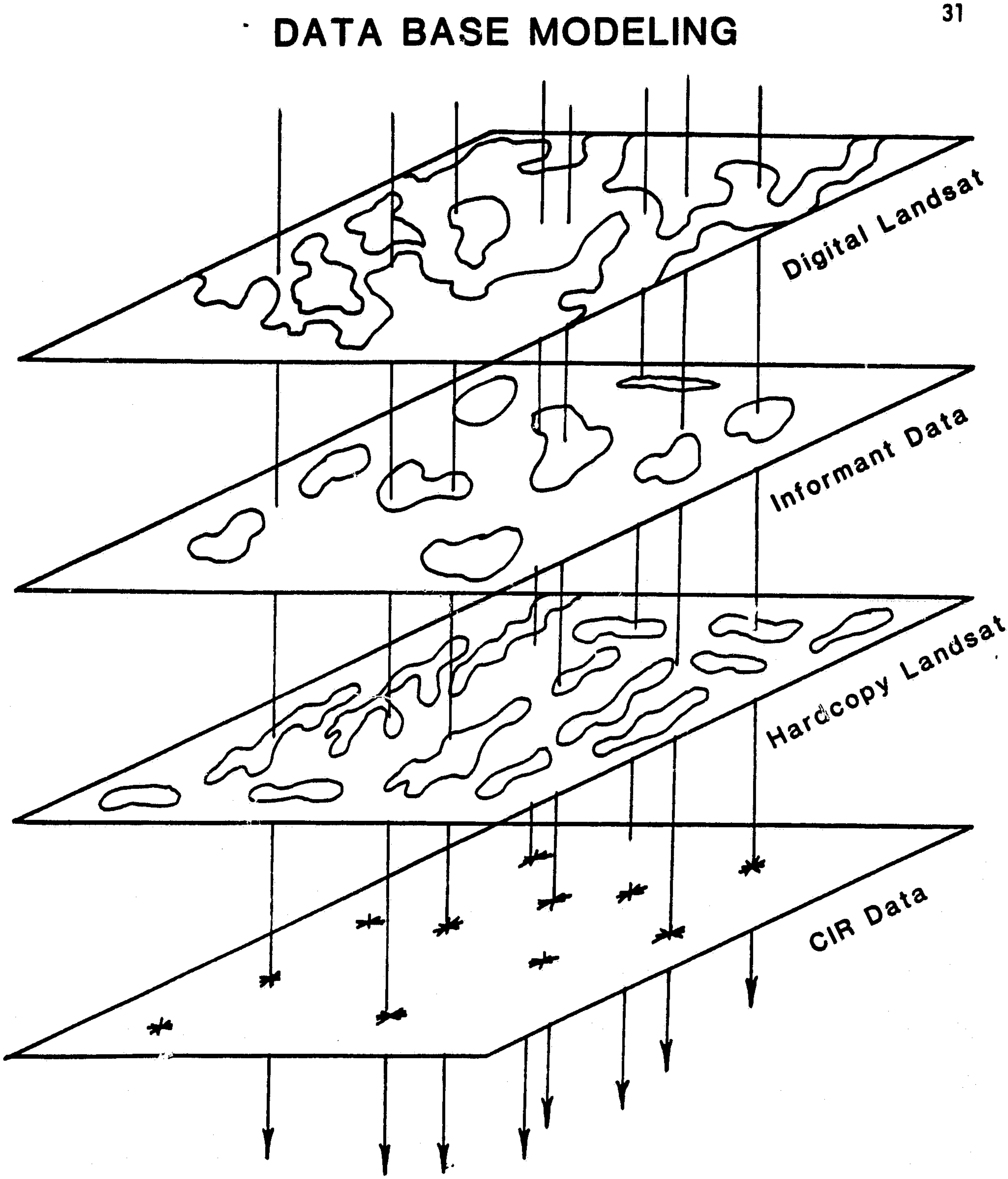

Figure 4. An illustration of data base modeling.

Table 10

Model: Correspondence of all Hardwood Location Techniques

Variable	Coded Values								Weight	
	0	1	2	3	4	5	6	7	Rel.	Pct.
4 Hardwood Forests-Hardcopy Landsat Imagery	1	9	0	0	0	0	0	0	25.00	25.00
6 Hardwood Forests-Informants	1	9	1	1	1	1	1	0	25.00	25.00
8 Hardwood Sites (low altitude color I.R.)	1	9	0	0	0	0	0	0	25.00	25.00
11 Landcover from Landsat Imagery	1	1	9	1	1	0	0	0	25.00	25.00

indicated that four location techniques; Landsat, Digital Landsat, Informant Data, and Color Infrared Imagery, corresponded in 20 fifty-acre cells. Three of the four techniques corresponded in 935 cells, and 2,360 cells were indicated by two of the four techniques. The digital Landsat analysis discriminated the highest acreage of predominantly hardwood stands, approximately 1.11 million acres, of which only 418,550 acres fell within the defined limits of "rough terrain" which was approximately 945,050 acres in extent. The remaining acreage was included in the study area but was not confined to rough topography; i.e., the Delta, major bottomlands, and areas between rough terrain regions.

In conclusion, the method of classification utilized proved to be both practical and economical in accomplishing the objectives of the study. The cost in CPU time was approximately $0.15/sq. mi. The information system is completed and it is available for use by cooperating agencies who wish to develop models. The method is cost effective--individual variable printouts cost about $3.00, and four-variable models of the study area cost $17.00.

SUMMARY AND CONCLUSIONS

The results indicate that had the original sampling scheme been followed; i.e., hardcopy Landsat and digital Landsat followed by aircraft data, the system would not only have been more "information-efficient," but also more cost effective in terms of pinpointing potential sites for aircraft coverage. In general, however, the study successfully fulfilled the objective which was to develop a cost-effective method of discriminating sites (forest stands) which had a high potential for representing unique biological communities. Of the 55 plots identified by MRSC personnel, 31 were visited during the first year by

the three botanists who were assessing existence or evidence of existence of rare or endangered plant species. Based on their reported findings, 17 of the 31 sites received a high rating, or a "success" percent of 54.8.

The following discussion involves a short critique with possible recommendations for any future work of a similar nature in the hope that some changes in procedure may produce better results. One of the major problems was that the aerial imagery used for the project was both too small in scale, and it was taken at a time of the year (early to mid-November) such that an easy, accurate, laboratory description of a site was somewhat difficult; identification of overstory species composition by photo-interpretation was a limiting factor. If one desired to manually interpret a site from remotely sensed data, it would be better to have imagery of scale 1:7,920 or 1:12,000 taken in late September or early October, well before leaf fall but after the visually noticeable chlorophyll shift. The existing aerial imagery (1:24,000), however, was still very useful in the field location and surveying of potential sites, and did allow for viable laboratory evaluations to be performed. For example, differentiation of hardwoods from pines, and separation of several individual hardwood species was possible; however, larger scale imagery taken at an earlier date would have raised the degree of confidence in overall species identification and laboratory evaluation.

With respect to the field survey of potential sites, it was later determined that not enough time was allotted for a complete quantitative evaluation of the overstory component on some of the sites. A five percent line cruise would be desirable for data collection if time and economic restrictions are not a limiting factor.

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APPENDIX I

Hardcopy Landsat Interpretation Key

Hardcopy Landsat Interpretation Key

Band 7--Winter Imagery

Tone	Features
Black	Water (rivers, streams (1st order only), lakes, etc.).
Darker Grays - Black	Wet - usually found within floodplains of river systems: indication of bottomland hardwood areas; swamps (cypress-swamp tupelo gum), etc. topography flat to hummocky to slightly rolling or lower slopes of rolling to dissected terrain; when specially arranged in squares, rectangles, etc., indication of wet to inundated fields; oxbows are discernible in this shade of gray.
Medium to Dark Grays	Forest; terrain usually rougher (i.e., slightly rolling to rolling to hilly); forest composition in dissected areas can be expected to be mostly hardwood-pine to pine-hardwood; areas of this shade that appear texturally smooth can be expected to be pine dominant (especially areas where color is medium to dark gray and spacial arrangement is in a quadrangular or straight sided polygonal form and shows a textural smoothness); clearcuts in a more advanced stage of succession may appear here.
Light Grays to Medium Grays	Fields, partially wooded areas (i.e., old fields, early succession clearcuts, selective cut woodlands), wet fields.
Lighter Gray Tones White	Indication of more reflective fields and cultural features. These areas which are more reflective demonstrate activity by man and can be determined easily by their spacial arrangement (i.e., linear features are roads, rectangular fields, etc.).

False Color Composite--Early Growing Season

This image was created by assigning bands 4, 5, and 7 different color filters, in this case band 4 - yellow, band 5 - red, and band 7 - blue, and then combining the bands to simulate a picture of the area imaged.

Dark Blue	Water.
Dark Bluish-Red	Wetland forests; i.e., bottomland hardwoods, floodplains of river systems and also pine-hardwood and hardwood-pine uplands.

Red	Generally an indication of forest lands and hardwoods in particular. The varying intensity can demonstrate different covertypes: (1) The smooth homogenous reds found along river paths can be expected to be predominantly bottomland hardwoods. (2) The reds where interspersed with blue-reds and blue-red-greens (grays) demonstrate dissected lands of upland hardwoods and hardwood-pine types. (3) The light reds, pinks and reddish-yellows are an indication of old fields in a young stage of succession, pastures containing some bush and scrub brush types.
Light Blue (Yellow-Blue)	Indicates some of the more reflective areas, sandy areas, and areas influenced by man; i.e., urban areas, some gravel deposits found along bluffs of the Tombigbee floodplain, sparesely vegetated pastures, and fresh clearcuts.
Yellow-Green Yellow-brightest tones	Indicates transportation systems (where spacially applicable), bare soil, gravel and other mineral mining deposit sites, and inert or highly reflective materials of agricultural land use types and urban usage.

APPENDIX II

An Example of a typical Site Survey Summary Sheet for Potential Site

Surveyor: Cameron, Turnipseed

Date: 4-30-80

Time:

SITE SURVEY SUMMARY SHEET

Name of Site: GR #1 5 Nov. 79 1:24,000 Roll 2 Site 19 Flt. 11 Frm. 1

Quad Name: Grenada MRC (1954) Quad Code: County: Grenada

Physiographic Province: Deep Loess Province Watershed:

Deep Loess Hill and Bluff Region

Directions to site

N

Coordinates:

Section 33 Township T23N Range R5E

S 4 T T22N R R5E

S T R

Base map of site attached: Yes No

Ownership - names, address (managed area?):

U. S. Army COE - Grenada Lake

Other individuals knowledgeable about site and/or EOs: None

Source of Lead: CIR and Landsat

Nature of Lead: Both

Site elevation (max/min): 170(flat) Size of area surveyed (acres): 110 acres

Current use: Forest

Threat: threatened potential threat secure

Index	Elements	Map Key	Searched	Found	New	Forms Filled
N/A						

SITE DESCRIPTION

Written description - Describe the site in the space below. Try to convey a mental image of the site features (including vegetation, significant animals and plants, aquatic features, land forms, geologic substrata, scenic qualities, etc.):

Topography: Flat bottomland; moist to saturated and inundated in old sloughs; old creek channel winds through site; seasonally and temporarily flooded. Negligible slope.

Soils: Falaya - Collins - Waverly association . . . Well drained to poorly drained silty soils formed in recent alluvium from the Yalobusha River and other streams.

The overstory on this site consists primarily of WaO, SgB, and WE, with some OcO, SG, SwCO, and Syc. The understory consists of AmHb, SgB, and WaO. The ground vegetation is fairly dense and consists of Tap-Hon., AmHb, Smilax spp., swamp privet, elderberry, GA, RMa, SgB, Viola spp., pawpaw, Am.Holly, Dec. Holly. We found one occurrence of Nandina spp. (rarely seen in woodlands).

This site is immediately below the Grenada Lake Dam and is frequently flooded following heavy rains when the spillway is opened. Access is through the campground on the north side of the spillway. Ground seepage from under the dam runs off into the site.

Evidence of disturbance - Describe the nature of disturbance or threat to site or elements. Discuss management considerations:

Considerable periodic flooding.

No potential human threat as yet.

Surrounding land use - Describe land use practices in the surrounding area (e.g., forestry, agriculture, recreation, residential, etc.):

Agriculture (directly west of site boundary)

Recreational (2000' west of site)

Residential - Grenada Lake, Spillway campgrounds

Site No. GR #1 Date Surveyed 4/30/80

No. of points ______ 10 BAF Prism

OVERSTORY

Species	Total No. of trees tallied	BA/acre (Sq.ft.)	DBH		Total Height	
			Mean (in.)	Range (in.)	Mean (ft.)	Range (ft.)
SgB	8	27	9	5-16	72	55-88
WaO	7	23	22	13-28	88	80-95
SG	6	20	17	10-24	92	60-108
WE	3	10	15	10-19	78	60-90
OcO	2	7	26	22-30	78	75-80
Per	1	3	11	-	70	-
Syc	1	3	16	-	92	-
SwCO	1	3	15	-	80	-
RMul	1	3	6	-	48	-
Elm	1	3	16	-	90	-

TOTAL BA/ac. ______

Site No. GR #1

Date Surveyed 4/30/80

No. of plots 3

1/20 acre circular plots

UNDERSTORY

Species	No/acre
AmHb	47
SgB	40
WaO	13
EHHb	13
Per	7
SG	7
WE	7
Elm	7
H	7

GROUND VEGETATION

Species occurring
AmHb, Jap.Hon.
Elm, Muscadine
Smilax spp.,ERC
Poison Ivy, WaO
Swamp Privet
RMa, GA
PawPaw, fern
H, Nandina
Blackberry, DeH
WiO, Switchcane
Elderberry, SgB
Viola, Indian,
Strawberry,
Am. Holly

SITE GR #1 ROLL #2 FRAME #1 DATE 4/30/80 CREW Turnipseed, Cameron

Point #	Species	DBH (in.)	Cr. Dia. (ft.)	Ht. (ft.)	Cr. Cl.	Comments
1	WaO	27	45	85	D	9 chs.N into bottom
	WaO	25	45	85	D	Terrain flat hummocky. Indication of seasonal
	WaO	13	34	82	D	of seasonal floodings. Soils mesic-saturated.
	WaO	13	28	80	D	Outlying sloughs with standing water.
	OcO	22	35	80	D	
	Per	11	25	70	D	
	WaO	23	40	88	D	Groundstory: AmHb,
						Japanese honeysuckle, Elm, Muscadine,
	UNDERSTORY:					Smilax spp., ERC, Poison Ivy, WaO,
	SgB	4		40-45		Swamp privet, RMa, GA
	SgB	4		40-45		
	WaO	3		35-40		
	AmHb	3		25-30		
	AmHb	3		30-35		
	AmHb	2		15-20		
	Per	5		45-50		
	AmHb	2		20-25		
	WaO	4		40-45		
	AmHb	3		30-35		
	AmHb	2		15-20		
	AmHb	2		15-20		

SITE GR#1 ROLL #2 FRAME #1 DATE 4/30/80 CREW Cameron and Turnipseed

Point #	Species	DBH (in.)	Cir. Dia. (ft.)	Ht. (ft.)	Cr.Cl.	Comments
2	WE	19	20	90	D	5 Chs. N. to bank of old creek
	WE	17	30	85	D	bed or oxbow. Topo continuously
	WaO	24	45	98	D	flat to hummocky
	SgB	6	10	60	OT	slope 0-5%
	WaO	28	42	95	D	
	SgB	7	15	75	I	Groundstory: Switchcane, WiO,
	SgB	6	15	64	OT	Jap. Honeysuckle, Swampprivet,
	WE	10	25	60	I	GA, poison ivy, elderberry,
	SgB	9	22	75	I	RMa, SgB, Indian Strawberry,
	SgB	11	20	72	CoD	Violets
	SgB	5	10	55	OT	
	SG	24	30	98	D	
UNDERSTORY:						
	SG	3		40-45		
	SgB	3		30-35		
	SgB	2		10-15		
	SgB	5		40-45		
	WE	4		35-40		
	SgB	2		20-25		

SITE GR#1 ROLL# 2 FRAME 1 DATE 4/30/80 CREW Turnipseed, Cameron

Point #	Species	DBH (in.)	Cr. Dia. (ft.)	Ht. (ft.)	Cr.Cl.	Comments
3	SG	10	22	90	-	5 Chs. N. to bottom high front
	Syc	16	46	92	-	bordered on both sides by creek
	SG	18	39	90	-	beaver activity noticed.
	SwCO	15	38	80	-	Groundstory: Same as before,
	SG	18	32	108	-	PawPaw, ferns, Am.Holly, H.
	RMul	6	22	48	-	Nandina, Blackberry, Dec.Holly
	SG	12	18	60	-	
	Elm	16	28	90	-	
	SgB	12	20	88	-	
	SG	18	35	105	-	
	SgB	16	30	84	-	
	OcO	30	20	75	-	
	UNDERSTORY:					
	EHH6	4	40-45			
	EHH6	5	40-45			
	Elm	2	10			
	H	5	50-55			

AmB - American Beech

AmE - American Elm

AmHb - American Hornbeam

BCh - Black Cherry

BCyp - Bald Cypress

BE - Boxelder

BG - Blackgum

BJO - Blackjack Oak

BO - Black Oak

BWal - Black Walnut

CBO - Cherrybark Oak

ChO - Chinkapin Oak

DeH - Deciduous Holly

DW - Flowering Dogwood

EC - Eastern Cottonwood

EHHHb - Eastern Hophornbeam

Elm

ERC - Eastern Red Cedar

GA - Green Ash

H - Hickory

Jap. Hon. - Japanese Honeysuckle

LLP - Loblolly Pine

LP - Longleaf Pine

Ma - Maple

NRO - Northern Red Oak

OcO - Overcup Oak

Per - Common Persimmon

PO - Post Oak

RB - River Birch

RMa - Red Maple

RMul - Red Mulberry

RO - Red Oak (unknown)

Sa - Sassafras

ScO - Scarlet Oak

SG - Sweetgum

SgB - Sugarberry

ShH - Shagbark Hickory

ShO - Shumard Oak

SiMa - Silver Maple

SLP - Shortleaf Pine

SoW - Sourwood

SpP - Spruce Pine

SRO - Southern Red Oak

SwCO - Swamp Chestnut Oak

Syc - American Sycamore

WA - White Ash

WaO - Water Oak

WE - Winged Elm

WiO - Willow Oak

WO - White Oak

YP - Yellow Poplar

APPENDIX III

MNHP/SAF Forest Cover Types, and SAF Type Classification of Heritage Plots

Adaptation of the Society of American Foresters' Cover Types of North America Classification Scheme by The Mississippi Heritage Program

Non-Forested Plant Associations

- .001 Freshwater Marsh
- .002 Prairie
- .003 Pine Savannah
- .004 Brackish Marsh
- .005 Saltwater Marsh
- .006 Salt Flat
- .007 Dune, Grass
- .008 Dune, Shrub
- .009 Saltwater Aquatics

.X00 Xeric Upland-Forest

- .X10 Xeric Oak-Hickory
  - .X11 Post Oak-Black Oak SAF 40
  - .X12 Scarlet Oak SAF 41
  - .X13 Chestnut Oak SAF 44

- .X20 Shortleaf Pine-Virginia Pine-Oak
  - .X21 Shortleaf Pine SAF 75
  - .X22 Shortleaf Pine-Oak SAF 76
  - .X23 Shortleaf Pine-Virginia Pine SAF 77
  - .X24 Virginia Pine-Southern Red Oak SAF 78
  - .X25 Virginia Pine SAF 79

- .X30 Loblolly Pine-Shortleaf Pine SAF 80

- .X40 Eastern Redcedar
  - .X41 Eastern Redcedar SAF 46
  - .X42 Eastern Redcedar-Pine SAF 47
  - .X43 Eastern Redcedar-Hardwoods SAF 48
  - .X44 Eastern Redcedar-Pine-Hardwoods SAF 49

- .X50 Longleaf Pine Forest
  - .X51 Longleaf Pine SAF 70
  - .X52 Longleaf Pine-Scrub Oak SAF 71
  - .X53 Southern Scrub Oak SAF 72

- .X60 Southern Redcedar SAF 73

.MOO Mesic Upland-Forest

- .M10 Mesic Oak-Hickory
  - .M11 White Oak-Red Oak-Hickory SAF 52
  - .M12 White Oak SAF 53
  - .M13 Northern Red Oak-Basswood-White Ash SAF 54
  - .M14 Northern Red Oak SAF 55

.M15 Northern Red Oak-Mockernut Hickory-Sweetgum SAF 56

.M20 Mixed Mesophytic

.M21 Yellow Poplar SAF 57
.M22 Yellow Poplar-White Oak-Northern Red Oak SAF 59
.M23 Beech-Sugar Maple SAF 60

.M30 Loblolly Pine Forest

.M31 Loblolly Pine SAF 81
.M32 Loblolly Pine-Hardwood SAF 82

.M40 Sweetgum-Yellow Poplar SAF 87

.M50 Laurel Oak-Willow Oak SAF 88

.M60 Beech-Southern Magnolia SAF 90

.M70 Live Oak SAF 89

.M80 Slash Pine Forest

.M81 Longleaf Pine-Slash Pine SAF 83
.M82 Slash Pine SAF 84
.M83 Slash Pine-Hardwood SAF 85
.M84 Slash Pine-Saw Palmetto

.H00 Bottomland Forest

.H10 Elm-Ash-Cottonwood

.H11 River Birch-Sycamore SAF 61
.H12 Silver Maple-American Elm SAF 62
.H13 Cottonwood SAF 63
.H14 Black Willow SAF 95
.H15 Sugarberry-American Elm-Green Ash SAF 93

.H20 Oak-Gum-Cypress

.H21 Swamp Chestnut Oak-Cherrybark Oak SAF 91
.H22 Sweetgum-Nuttall Oak-Willow Oak SAF 92
.H23 Overcup Oak-Water Hickory SAF 96
.H24 Bald Cypress SAF 101
.H25 Bald Cypress-Water Tupelo SAF 102
.H26 Water Tupelo SAF 103
.H27 Pond Cypress SAF 100
.H28 Sycamore-Pecan-American Elm SAF 94

.H30 Atlantic White Cedar SAF 97

.H40 Slash Pine-Swamp Tupelo SAF 99

.H50 Sweetbay-Swamp Tupelo-Red Maple SAF 104

.H60 Titi

SAF Type Classification of Heritage Plots from Field Data

SAF types were assigned by comparing the two or three most frequently occurring species in the main stand canopy of the plots to the listed "dominant" species groups of the SAF classification.

Site	Society of American Foresters Forest Cover Types	Physiographic Province Plant Community Designations
CHOC. 1	SAF 52 (plus sweetgum), SAF 76	FW
CHOC. 2	SAF 52, upper slopes (plus sweet-gum; minus hickory) SAF 87, lower slopes and bottoms (plus ash, American beech)	FW
CHOC. 4	SAF 52, upper slopes SAF 82, lower slopes and bottoms (plus white oak, shagbark hickory, sweetgum)	FW
GR. 1	SAF 91, SAF 93, SAF 96	NC
GR. 6	No adequate SAF type	NC
GR. 8	SAF 52	FW
GR. 9	SAF 52, upper slopes SAF 87, lower slopes and bottoms (plus elm, green ash)	NC
GR. 10	SAF 91, SAF 92 (plus water oak, winged elm, blackgum, minus Nuttall oak	NC
GR. 14	SAF 52, upper slopes SAF 60, lower slopes and bottoms (plus water oak, green ash, sweetgum; minus sugar maple	LB
GR. 15	SAF 40, upper slopes (plus blackjack oak) SAF 52, upper slopes (plus sweetgum) SAF 52, lower slopes and bottoms (plus willow oak)	FW
KEM. 1	SAF 57 (plus water oak, blackgum)	PR
KEM. 2	SAF 91 (plus blackgum, hickory, willow oak)	PR

LA. 2	SAF 52, upper slopes SAF 57, lower slopes and bottoms (plus American beech, cherrybark oak)	FW
LA. 3	SAF 62, upper slopes (plus blackgum) SAF 52, lower slopes and bottoms SAF 53, lower slopes and bottoms (plus water oak)	FW
LA. 6	SAF 40, SAF 52	NC
LA. 7	SAF 52	FW
LAUD. 1	SAF 52, SAF 87 (plus sweetbay)	NC
LAUD. 3	SAF 90 (plus bigleaf magnolia)	FW
LAUD. 4	SAF 91, SAF 92 (plus spruce pine, water oak, American beech)	NC
PA. 1	SAF 40, upper slopes (plus blackjack oak, southern red oak) SAF 40, lower slopes and bottoms plus sweetgum, cherrybark oak)	NC YD
PA. 2	SAF 91, SAF 92, SAF 96, SAF 101	YD
PA. 3	SAF 91, SAF 92 (plus water oak)	YD
PA. 4	SAF 91, SAF 92 (minus Nuttall oak)	YD
TA. 3	SAF 52, SAF 59, SAF 60	LB
TA. 4	SAF 60, SAF 87	LB
TA. 5	SAF 40, SAF 82, upper slopes SAF 60, lower slopes and bottoms (plus red maple)	LB
WEB. 1	SAF 91, SAF 96, SAF 101, SAF 92 (plus sweetgum, water oak)	FW
YA. 2	SAF 52 (plus American beech, sweetgum, shortleaf pine)	FW
YA. 3	SAF 56, upper slopes (plus cherrybark oak; minus sweetgum) SAF 87, lower slopes and bottoms (plus blackgum, hickory)	LB